ORIGINAL RESEARCH

Prevalence and Risk Factors of Brain Infarcts and Associations With Cognitive Performance in Tenants of Marginal Housing

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***Background*—**Homeless and vulnerably housed individuals are at increased risk for multimorbidity compared with the general population. We assessed prevalence of brain infarcts on neuroimaging and associations with vascular risk factors and cognitive performance in a prospective study of residents living in marginal housing.

***Methods and Results*—**Two hundred twenty-eight participants underwent structured clinical interviews, targeted clinical, laboratory, and neuropsychological assessments, and magnetic resonance imaging with T_1, T_2-fluid-attenuated inversion recovery and susceptibility-weighted images. Subjects underwent cognitive testing to assess premorbid IQ, verbal learning and memory, inhibition, sustained attention, mental flexibility, and decision making. In this sample (mean age 44.0 years [SD 9.4], 77% male), prevalence of conventional vascular risk factors was lower than in the general population apart from tobacco use (94%). Ten-year Framingham risk for any cardiovascular event was 11.4%±9.2%. Brain infarcts were present in 25/228 (11%). All were ischemic (40% cortical, 56% lacunar, 4% both). Participants with infarcts were older than those without (48.9±9.4 versus 43.4±9.2, P=0.006). In a multivariable regression analysis, only age remained a significant predictor of brain infarcts (odds ratio 1.08, 95% CI1.02–1.14, P=0.004). After controlling for age and education, the presence of infarct was a significant predictor of impaired decision making on the Iowa Gambling Task of decision making (β −28.2, 95% CI −42.7 to −14.1, P<0.001).

***Conclusions*—**Prevalence of infarcts on neuroimaging in this disadvantaged, community-dwelling cohort was much higher than expected for age and was associated with impaired decision making. Further research is needed to identify individuals at highest risk who may benefit from targeted preventative strategies. **(*J Am Heart Assoc*. 2019;8:e011412. DOI: 10.1161/JAHA.118.011412.)**

Key Words: cognition • drug abuse • health disparities • homeless people • infarct or infarction

Socioeconomic disparities are associated with burden of vascular risk factors as well as stroke incidence, outcomes, and recurrence.[1–4] In high-income nations, individuals who are homeless or living in marginal housing represent the most disadvantaged end of the socioeconomic spectrum. Homeless and vulnerably housed individuals may have reduced access to health care, and therefore may have suboptimal management of modifiable vascular risk factors.[2] Furthermore, these individuals may have additional health issues, including substance use and dependence, mental illness, antipsychotic use, and chronic viral infections such as HIV and hepatitis. Previous studies examining the relationship between homelessness and vascular risk have yielded inconsistent results. Some reported an increased risk of future cardiovascular events,[5] while others found that risk was comparable to that of the general population.[6,7]

Single room occupancy (SRO) hotels are found in many North American urban centers. They are a form of marginal

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Accompanying Tables S1 through S5 and Figure S1 are available at https://www.ahajournals.org/doi/suppl/10.1161/JAHA.118.011412

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Clinical Perspective

What Is New?

- In a younger (mean age 44 years) community-dwelling cohort of participants living in marginal housing and without a major burden of conventional vascular risk factors, brain infarcts on baseline neuroimaging were highly prevalent (11%) and mostly (92%) in the absence of a self-reported history of stroke.
- After adjustment for age and education, infarcts on neuroimaging were associated with worse performance on the Iowa Gambling Task, a task of complex decision making and risk-taking.

What Are the Clinical Implications?

- Clinicians caring for individuals living in marginal housing or without a fixed address should be aware of the high prevalence of "silent" brain infarcts and their association with impaired decision making, and should advocate for housing and community services to help optimize access to preventative care.

housing that is frequently subsidized in Canada, with low barriers to entry, and are often the only alternative to homelessness for individuals with very low incomes. Longitudinal health studies are more feasible with SRO residents than with homeless individuals. SRO residents have been shown to share a similar likelihood to homeless individuals[8] of having unmet healthcare needs and high mortality rates.[9] The Hotel study is a longitudinal investigation of multimorbidity in a cohort of SRO residents in the Downtown Eastside of Vancouver, Canada.[10] This neighborhood has one of the lowest median incomes in Canada and is home to a vulnerable urban population.[11] We explored the prevalence of brain infarcts on baseline neuroimaging and their association with measured vascular risk factors and cognitive performance. Based on any positive findings concerning infarcts, our goal was to develop hypotheses for future analyses or prospective studies, including the possibility of a comprehensive evaluation of small vessel disease. To our knowledge, there have been no other comparable cohorts of participants who are homeless or living in tentative housing that have included neuroimaging.

Methods

Study Population

All participants were adults over the age of 18 years and living in SRO hotels in Vancouver's Downtown Eastside. Staggered recruitment took place at 4 sites from November 2008 to July 2011. The study was approved by the Clinical Research Ethics Board at the University of British Columbia and Simon Fraser University in accordance with Canadian Tri-Council policy. All participants provided written consent at enrollment. Baseline assessment methods were described previously.[10] Briefly, upon recruitment, participants underwent a structured interview including demographic characteristics, general medical, psychiatric, social, and occupational history, including cardiovascular risk factors, prior stroke and lifetime substance exposure (including tobacco, alcohol, and prescribed as well as nonprescribed drugs and substance use). The Global Assessment of Function score was rated by a research assistant based on this interview. Participants were tested for HIV, hepatitis B virus and hepatitis C virus serology, hemoglobin A1C percentage, and LDL concentrations. Qualitative polymerase chain reaction was collected for those positive for the hepatitis C virus antibody. Height and weight were measured, and blood pressure was recorded 3 times via an automatic blood pressure measurement device with subjects in seated position, and the mean of these 3 measurements was used for further analysis.

Neuroimaging

The neuroimaging protocol is detailed in Table S1. T_1, T_2-fluid-attenuated inversion recovery, and susceptibility-weighted images sequences were obtained on a Philips Achieva 3T MRI scanner (software Version 2.6.3.5). Software version and coil selection were maintained throughout the entire course of the study to ensure consistency of data quality.

Neurocognitive Assessments

Detailed neurocognitive assessment methodology has been previously published.[12] Briefly, testing was carried out by trained research assistants supervised by a psychologist (A.E.T.). Tests included measures of estimated premorbid intelligence (Using Wechsler Test of Adult Reading), verbal learning and memory (Hopkins Verbal Learning Test Revised), inhibition (Stroop Color-Word Test), sustained attention (Rapid Visual Information Processing subtest), mental flexibility (Intra-Dimensional Extra-Dimensional subtest, and decision making (Iowa Gambling Task [IGT]). Results from sessions closest in time to the date of baseline imaging were used for analysis. All subjects had neurocognitive testing within 1 year of their baseline scan. Cognitive testing occurred on the same day as neuroimaging in 89% of participants, and cognitive testing within 1 month of neuroimaging occurred in 98% of participants.

Analysis

The Framingham multiple risk factor equation was used to calculate 10-year risk for vascular events (including coronary

death, myocardial infarction, coronary insufficiency, angina, ischemic stroke, hemorrhagic stroke, transient ischemic attack, peripheral artery disease, and heart failure). Morbidity from self-reported medical history questionnaires was used to generate a modified Charlson Comorbidity Index score (details in Data S1). Since brain infarction was the outcome of interest in our study, points on the Charlson Comorbidity Index given for previous stroke were removed to adjust for multimorbidity for subsequent analysis.

Scans were reviewed separately by a neuroradiologist (A.T.V.) and a team of 2 neurologists (T.S.F., W.J.P.). Infarct type (ischemic versus intracerebral hemorrhage) and location and morphology (lacunar, cortical, both, other, uncertain) were documented. Disagreements were identified in 7/228 subjects and settled by adjudication by an additional senior neuroradiologist (M.K.S.H.). For those study participants with infarcts or other findings of clinical significance on their neuroimaging, their family physicians received a letter from the study team recommending further clinical assessment as required.

Those with and without neuroradiological evidence of previous infarction were compared on vascular risk factor variables using *t* tests, Mann–Whitney *U* test, or χ^2 tests as appropriate. A logistic regression model was constructed to examine the effects of variables identified as significant on univariable analyses ($P<0.05$) on the odds of having an infarct on neuroimaging. Multiple imputation using chained equations accounting for possible monotonicity was completed for missing values. Application of multiple imputation using chained equations mitigates statistical uncertainty within the imputations and allows for inclusion of continuous or binary data.[12]

A multivariable linear regression was used to explore the association between infarction on neuroimaging and cognitive performance, controlling for effects of age and education. Multimorbidity using the modified Charlson Comorbidity Index was also considered as a covariable for the model but was excluded because it was not significantly correlated with performance of any of the 5 tasks.

Statistical analyses were conducted using IBM SPSS Statistics for Windows, version 21 (Armonk, NY). Statistical tests were 2-sided with significance level set at $P<0.05$ with no adjustments for multiple comparisons. Study data are available from the corresponding author upon reasonable request.

Results

Of 406 residents who were approached, 308 agreed to participate, and 228 completed baseline neuroimaging and were included in the present analysis (Table 1). Participants were predominantly male (77%) and mainly in young adulthood and middle age (Figure S1). Three-quarters had a prior history of homelessness. Compared with the general Canadian population of working age, a much lower proportion had completed at least a high school education (25% versus 80%).[13] Diagnosis of lifetime history of substance dependence was common, especially for injected drugs (82% with history of regular use) but also for alcohol (48%). A substantial proportion of the cohort had positive serology for HIV (17%), hepatitis B virus (38% core antibody positive), and hepatitis C virus (68%) infections.

Conventional vascular risk factors including hypertension, diabetes mellitus, and obesity were lower than in the general Canadian population. Rates of tobacco smoking, however, were very high at 94%. Detailed age-specific rates of morbidity for these conditions for the general population were not available from Statistics Canada to calculate age- and sex-standardized expected prevalence and a meaningful standardized morbidity ratio. In those 167 participants with complete data for a Framingham risk calculation (also excluding participants under the age of 30 years, for whom the equation was not validated), the mean 10-year risk of a cardiovascular event was estimated to be 11.4%±9.2% (range 1.2–48.9%). The median modified Charlson Comorbidity Index score was 3 (mean 3.43, SD 2.95, range 0–11) with 39% of participants having a score ≥5. The median Global Assessment of Function score for this cohort was 35, commensurate with major impairment in several spheres, such as judgment, thinking, mood, or interpersonal relationships (mean 38, SD 11, range 15–70).

Prevalence of infarction on brain magnetic resonance imaging (MRI) was 11% (Table 2). This was more than double the rate of self-reported history of prior stroke (4%). All infarcts were ischemic (Figure). Cortical morphology was present in 36% and 56% met Standards for Reporting Vascular Changes on Neuroimaging (STRIVE) criteria[14] for lacunar infarction. Details on infarct location are available in Table S2. Comparing participants with lacunar to cortical infarcts, there tended to be a longer history of intravenous drug use in those with lacunar infarcts (Table 3) with no significant differences in other classes of substance use.

Participants with infarcts were older compared with those without (48.9±9.4 versus 43.4±9.2 years, $P=0.006$) and had a shorter duration of total homelessness (1.84±3.16 versus 3.39±5.44 years, $P=0.019$). No other variables differed significantly between the 2 groups (Table 4). Multiple imputations for missing values did not change our results. Age and duration of homelessness were not significantly correlated. With multivariable logistic regression, only age remained a significant predictor of infarcts seen on baseline imaging (odds ratio 1.08, 95% CI 1.02–1.14, $P=0.004$) (Table S3).

Performance on a task of decision making (IGT) was significantly poorer in those with infarcts after controlling for

Table 1. Participant Demographics

	No Infarct on Imaging (N=203)	Infarct on Imaging (N=25)	Canadian Population 2011
Age (y) (missing=0)			
Mean	43.4 (SD 9.2)	48.9 (SD 9.4)	
Range	23.3–63.2	33–62.4	
Sex (missing=0)			
Male	156/203 (77%)	20/25 (80%)	51%
Race-ethnicity* (missing=0)			
White	118/203 (58%)	15/25 (60%)	67.3%
First Nations	63/203 (31%)	6/25 (24%)	2.1%
First Nation Mixed	12/203 (6%)	1/25 (4%)	0.9%
Other	9/203 (4%)	3/25 (12%)	30.1%
Monthly income, Canadian $ (missing=4)			
Median	$871 (SD 538)	$919 (SD 476)	$2150[†]
Range	$200–$5600	$235–$2700	
History of homelessness (missing=3)			
Yes	154/201 (76.6%)	11/24 (46%)	
Total y of homeless (missing=4)			
Mean	3.4 (SD 5.4)	1.8 (SD 3.16)	
Range	0–39 y	0–11.4 y	
Highest educational attainment (missing=0)			
0–8 y	39/203 (19%)	6/25 (24%)	6.4%
8–11 y	112/203 (55%)	14/25 (56%)	13.4%
12 y	28/203 (14%)	4/25 (16%)	19.8%
>12 y	24/203 (12%)	1/25 (4%)	60.4%
Body mass index (missing=4)			
Mean	22.8 (SD 4.2)	23.6 (SD 3.6)	
≥25	45/203 (22%)	7/25 (28%)	34.1%
≥30	0	0	18.4%
HgA1c (missing=8)			
≥6.5%	3/195 (1.5%)	1/25 (4%)	
≥7.0%	2/195 (1%)	1/25 (4%)	
Self-reported diabetes mellitus (missing=8)			
Yes	7/196 (3.6%)	3/24 (13%)	6.1%
LDL cholesterol in mmol/L (missing=11)			
Mean	2.2 (SD 0.83)	2.5 (SD 0.96)	
≥2 mmol/L	99/192 (52%)	16/25 (64%)	
≥3.5 mmol/L	14/192 (7.3%)	3/25 (12%)	
Self-reported dyslipidemia (missing=9)			
Yes	3/195 (1.5%)	1/24 (4.2%)	
Systolic blood pressure (missing=45)			
Mean (mm Hg)	115 (SD 13.8)	117 (SD 13.1)	

Continued

Table 1. Continued

	No Infarct on Imaging (N=203)	Infarct on Imaging (N=25)	Canadian Population 2011
≥130 mm Hg	22/164 (13.4%)	3/19 (16%)	
≥140 mm Hg	8/164 (4.8%)	1/19 (5%)	
Diastolic blood pressure (missing=45)			
Mean (mm Hg)	75 (SD 11.3)	78 (SD 8.5)	
≥80 mm Hg	47/164 (25.7%)	9/19 (47%)	
≥90 mm Hg	16/164 (8.7%)	2/19 (10.5%)	
Self-reported hypertension (missing=9)			
Yes	12/199 (6%)	4/25 (16%)	17.6%
Pack y (missing=1)			
Mean	19.6 (SD 15.9)	27.8 (SD 26.6)	
Range	0–111	0–109	
>10 pack-y	138/202 (68%)	19/25 (76%)	
Active smoker (missing=1)			
Yes	191/202 (94.6%)	22/25 (88%)	19.9%
History of regular use of injected drugs (missing=1)			
Yes	165/202 (81.7%)	22/25 (88%)	
History of alcohol dependence (missing=1)			
Yes	95/202 (47%)	15/25 (60%)	
History of marijuana dependence (missing=1)			
Yes	92/202 (46%)	11/25 (44%)	
HIV status (missing=0)			
HIV not on ARV	13/203 (6.4%)	1/25 (4%)	
HIV on ARV	22/203 (11.3%)	3/25 (8%)	
Hepatitis C virus status (missing =9)			
Ab pos, PCR neg	35/195 (18%)	3/24 (13%)	
PCR positive	99/195 (51%)	13/24 (54%)	
Hepatitis B virus status (missing=3)			
Core ab positive	74/200 (38%)	12/25 (48%)	
Surface ag positive	3/200 (1.5%)	0/25	
Modified Charlson score (missing=0)			
Mean	3.47 (SD 2.99)	3.44 (SD 2.79)	
0	35/203 (17%)	3/25 (12%)	
≥5	60/203 (30%)	7/25 (28%)	
Global assessment of function (missing=0)			
Mean	38 (SD 35)	35 (10.2)	
Range	15–70	19–58	
Estimate of IQ (WTAR) (missing=5)			
Mean	96 (SD 8.6)	97 (SD 9.9)	
Range	75–122	78–113	
10-y Framingham CVD (excluded 23 for age ≤30 y, missing component 38)			
Mean	10.9 (SD 8.5%)	15.4 (SD 13.0%)	

Continued

Table 1. Continued

	No Infarct on Imaging (N=203)	Infarct on Imaging (N=25)	Canadian Population 2011
<10%	92/148 (62%)	8/19 (42%)	
10%–20%	56/148 (38%)	11/19 (58%)	
>20%	22/148 (15%)	5/19 (26%)	
Range	1.2%–44.4%	1.7%–48.9%	

HgA1c indicates hemoglobin A1c; ARV, antiretroviral drugs; CVD, cardiovascular disease; PCR, polymerase chain reaction; WTAR, Wechsler Test of Adult Reading.
*Reported for Vancouver, BC; proportions of individuals by ethnicity are highly variable between different Canadian cities.
†Based on annual income of unattached individuals.

effects of age and education (β −28.2, 95% CI −42.7 to −14.1, $P<0.001$, ΔR^2 −0.072). IGT was also the only task for which the combined model of age and education alone was not significantly predictive of performance (Table 5).

Discussion

Within this socioeconomically disadvantaged, community-dwelling cohort of relatively young age (mean age 44.0 ±9.4 years), there was a very high prevalence of chronic ischemic infarcts (11%) found on baseline MRI. Of the 25 patients with infarcts on neuroimaging, 23 did not report a history of stroke. Silent brain infarcts (SBI) are associated with cognitive decline[15,16] and increased risk of recurrent stroke.[17,18] The prevalence of SBI on MRI in community-dwelling cohorts varies widely based on age and geography, in addition to imaging modality.[19] In a Canadian population-based neuroimaging cohort, 2.8% of 40- to 49-year-olds and 5.9% of 50- to 59-year-olds had silent brain infarcts on MRI.[20] Within a Korean cohort of healthy volunteers of an age similar to our cohort (mean age of 49.0±7.7 years), prevalence of SBI on MRI was 5.8%.[21] A recent meta-analysis found an SBI prevalence in community-dwelling cohorts (mean age 50–55 years) of 5%.[19] In contrast to community-based cohorts with symptomatic stroke, where cardioembolic and large artery cortical infarcts are each as common as lacunar infarcts,[22,23] asymptomatic lacunar infarcts are the most frequent subtype of SBI.

The majority of infarcts in this cohort were also lacunar. Lacunar infarcts are generally caused either by intracranial large artery disease occluding a penetrating artery, or occlusion of a single penetrating artery by microatheroma or lipohyalinosis.[24] Conventional vascular risk factors such as hypertension, diabetes mellitus, dyslipidemia, and smoking are associated with increased risk of both lacunar and atheroembolic stroke.[25] However, similar to a study of homeless participants from Toronto,[6] the only traditional vascular risk factor more common in this cohort compared with the Canadian general population was tobacco use. The mean calculated 10-year Framingham risk for cardiovascular disease in this study population was 11.4%, compared with the general Canadian population at 8.9%.[26] However, this metric likely underestimates vascular risk for this cohort because it does not account for risks associated with other factors, such as chronic infection, injection drug use, and social determinants of cardiovascular health.

Given the high prevalence of injection drug use in this cohort and secondary risk of endocarditis, one explanation for the high prevalence of lacunar over cortical infarcts may be the "healthy survivor" effect. Cortical strokes may be more debilitating than lacunar events. Individuals with significant poststroke disability would be unable to live independently in a SRO. This explanation may also apply to the increased prevalence of infarcts in those with shorter duration of

Table 2. Prevalence of Infarcts on MRI

	Infarct on Baseline Imaging	No Infarct
Self-reported history of stroke	2	7
No reported history of stroke	23	193
Missing	0	3

MRI indicates magnetic resonance imaging.

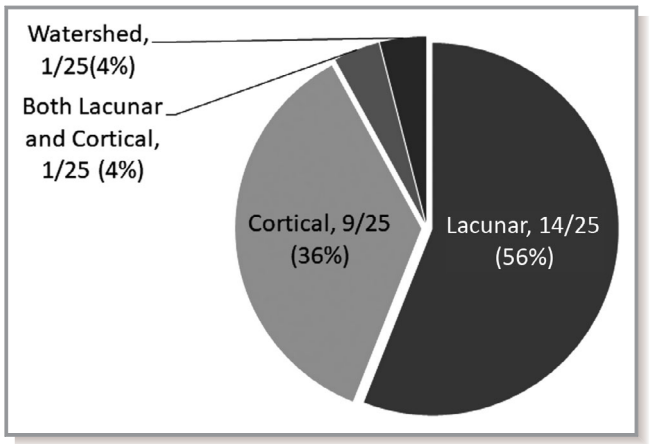

Figure. Infarct morphology.

Table 3. Substance Use and Infarct Morphology

	Years of Substance Use						
	Alcohol	Cannabis	Cocaine	Amphetamine	Hallucinogen	Opiate	IVDU
Cortical (n=9)							
Median	5	10	7.5	0.5	0	0	3.5
Mean	9.50	13.78	9.94	4.50	1.86	3.94	5.38
Lacunar (n=14)							
Median	20	4.5	10	3.5	0	6	20
Mean	18.09	8.79	14.45	4.65	0.50	12.75	20.36
P value of Mann–Whitney *U* test	0.364	0.734	0.904	0.962	0.837	0.11	0.041

IVDU indicates intravenous drug use.

homelessness (a major risk factor for early mortality),[27] and may also explain why no intracerebral hemorrhages, which are more disabling than ischemic strokes,[28] were observed in this cohort. In contrast, intracerebral hemorrhages and cerebral microbleeds, a marker of intracerebral hemorrhage risk, were found to be highly prevalent in a Boston-based inner-city cohort of young stroke patients with a median age of 44 years, similar to our population.[29]

Cognitive impairment is common both in homeless populations, and after stroke. One recent meta-analysis estimated the prevalence of cognitive impairment among homeless cohorts to be 25%,[30] with some studies reporting much higher prevalences, up to 72%.[31] This study used a battery of neurocognitive tasks that offer a more comprehensive assessment than the Montreal Cognitive Assessment or Mini-Mental State Examination, which are screening measures limited by ceiling effects. Interestingly, presence of an infarct on MRI was not associated with poorer performance on verbal learning and memory, inhibition, sustained attention, or mental flexibility but did significantly impact performance on a relatively complex decision making task involving risk assessment. In our cohort, IGT performance overall was poor in participants both with and without infarcts, but those with infarcts demonstrated an increased preference for "risky" decks compared with safe ones. Impaired performance on the IGT has been associated both with poverty[32,33] as well as history of substance use disorders.[34] There are little data on IGT testing after stroke, but 1 small study found that subjects with frontal infarcts showed a persistent preference for riskier decks compared with healthy controls, where as those with cerebellar infarcts did not.[35] The relatively few observations within this cohort did not allow us to examine for the effect of location, laterality, or stroke mechanism. Further research with robust poststroke data is needed to interpret the clinical significance of our findings on cognitive tasks. Multiple additional structural brain factors beyond infarcts may modify cognitive performance in this cohort. The relationship between burden of white matter hyperintensities and other markers of cerebral small vessel disease are associated with cognitive performance[36] and are being characterized in our study cohort. We have previously shown that other neuroimaging findings in this study population, such as white matter diffusion alterations[37] as well as congenital anomalies,[38] are also associated with cognitive performance.

Our study has limitations. First, participation in the Hotel study is voluntary, and the demographics of our cohort may not fully reflect that of all SRO residents in the DTES (downtown Eastside of Vancouver). Like other voluntary community-dwelling cohorts, there is potentially "healthy participant" bias and the burden of cerebrovascular disease measured may be an underestimate of the true prevalence. The initial response rate of all residents approached was 76%, but 80 of those 308 participants did not complete baseline imaging for a variety of reasons including contraindications for MRI (extracranial metal detected by x-ray, intracranial metal because of previous neurosurgery), movement disorder too severe to allow imaging, death, and dropout before baseline imaging. Despite the extensive involvement required of participants and the additional complexities of arranging neuroimaging in a cohort with tentative housing, a final participation rate of 56% is comparable to that of other contemporary voluntary community-based cohorts.[39–42] Of interest, many long-standing studies such as the Behavioral Risk Factor Surveillance Survey have reported a declining trend of participation since the time of their establishment, with 2017 response rates close to 45%[43] compared with 71% in 1993.[44] It is particularly important to be mindful of this declining participant rate and possible variable impact of the "healthy participant" bias when interpreting epidemiological trends across time. Reassuringly, the baseline demographics of our study is similar to those reported in other studies of SRO residents on Vancouver's Downtown Eastside (Table S4)[45–48] and other vulnerably housed and homeless

Table 4. Univariate Risk Factor Comparisons

Variable		No Infarct on Imaging (N=203)	Infarct on Imaging (N=25)	Univariate Comparisons
Age (missing =0)*	Mean (y)	43.4 (SD 9.2)	48.9 (SD 9.4)	T Score=−2.818, *P*=0.005
Sex (missing=0)†				
Male		156/203 (77%)	20/25 (80%)	χ^2=0.126, *P*=0.719
Race-ethnicity (missing=0)†				
White		118/203 (58%)	15/25 (60%)	χ^2=2.929, *P*=0.491
First Nations		63/203 (31%)	6/25 (24%)	
First Nation mixed		12/203 (6%)	1/25 (4%)	
Other		9/203 (4%)	3/25 (12%)	
Total y of homeless (missing=4)‡	Median	1.3 (IQR 5)	0 (IQR 2)	Z score=−2.341, *P*=0.019
Highest educational attainment (missing=0)‡	Median	10 (IQR 3)	10 (IQR 3)	Z score=−0.981, *P*=0.326
Body mass index (missing=4)‡	Median	22.2 (IQR 4.1)	22.9 (4.7)	Z score=−1.288, *P*=0.198
HgA1c (missing=8)‡	Median	5.5 (IQR 0.5)	5.4 (IQR 0.6)	Z score=−0.117, *P*=0.907
LDL cholesterol (missing=11)‡	Median (mmol/L)	2.1 (SD 1.1)	2.5 (IQR 1.3)	*Z* score=−1.612, *P*=0.107
Systolic blood pressure (missing=45)‡	Median (mm Hg)	114 (IQR 18)	121 (IQR 16)	*Z* score=−1.103, *P*=0.270
Diastolic blood pressure (missing=45)‡	Median (mm Hg)	75 (IQR 12)	81 (IQR 13)	*Z* score=−1.265, *P*=0.206
Pack y (missing=1)‡	Median	17.0 (IQR 22.5)	16.8 (IQR 17.9)	*Z* score=−1.198, *P*=0.231
History of regular use of injected drugs (missing=1)†	Yes	165/202 (81.7%)	22/25 (88%)	χ^2=0.737, *P*=0.638
History of alcohol dependence (missing=1)†	Yes	95/202 (47%)	15/25 (60%)	χ^2=1.628, *P*=0.420
History of marijuana dependence (missing=1)†	Yes	92/202 (46%)	11/25 (44%)	χ^2=0.145, *P*=0.881
HIV status (missing=0)†				
HIV not on ARV		13/203 (6.4%)	1/25 (4%)	χ^2=0.241, *P*=0.875
HIV on ARV		22/203 (11.3%)	3/25 (8%)	
HCV status (missing =9)†				
Ab pos, PCR neg		35/195 (18%)	3/24 (13%)	χ^2=0.442, *P*=0.924
PCR pos		99/195 (51%)	13/24 (54%)	
HBV status (missing=3)†				
Core ab positive		74/200 (38%)	12/25 (48%)	χ^2=1.801, *P*=0.491
Surface ag positive		3/200 (1.5%)	0/25	
Modified Charlson Score (missing=0)‡	Median	3 (IQR 4)	4 (IQR 5)	Z score=−0.264, *P*=0.792

HgA1c indicates hemoglobin A1c; ARV, antiretroviral drugs; IQR, interquartile range; HBV, hepatitis B virus; HCV, hepatitis C virus; PCR, polymerase chain reaction.
*T scores; independent samples *t* test.
†*Z* scores; Mann–Whitney *U* test for continuous variable felt to have significant deviations from normal distribution.
‡χ^2 for comparison of frequencies.

participants in other Canadian cities (Table S5) conducted within the same time frame.[47,48]

Second, our cohort may be underpowered to show significant differences in other risk factors in participants with and without brain infarcts. Furthermore, the number of infarcts observed in the cohort did not allow for sufficient power to properly explore interactions that may have impacted the relationship between cognitive performance and presence of infarction, such as age and educational attainment. Next, because this was a retrospective analysis, some relevant information related to risk factor assessment for stroke and SBI, including vascular imaging and information on high-risk cardioembolic sources, was not captured. Last, the demographic characteristics of Vancouver's SRO population may differ from that of other vulnerably housed North American cohorts, potentially limiting generalizability.

Table 5. Neurocognitive Testing

	Stroop		Delayed Hopkins Verbal Learning Test		Rapid Visual Information Processing		Iowa Gambling Task		Log Transformed Intra-Dimensional Extra-Dimensional Set Shift	
	Infarct −	Infarct +	−	+	−	+	−	+	−	+
N	193	24	198	24	186	24	180	23	193	24
Mean	35.99	31.83	6.09	5.96	0.87	0.84	−1.50	−30.70	−1.58	−1.73
SD	10.01	10.99	2.85	3.11	0.06	0.06	32.36	24.92	0.38	0.28
Model 1 R^2 with age and education	0.099		0.054 (0.0537)		0.056		0.012		0.116	
Model 2 R^2 with age, education, and infarct	0.104		0.054 (0.0544)		0.064		0.084		0.121	
ΔR^2 With stroke effect	0.005		0.0007		0.009		0.072		0.004	
ΔR^2 P value*	0.291		0.690		0.167		<0.001		0.300	
Age	B=−0.226 (95% CI −0.371 to −0.081), P=0.002		B=−0.054 (95% CI −0.095 to −0.014), P=0.009		B=−0.001 (95% CI −0.002 to 0.000), P=0.020		B=−0.122 (95% CI −0.600 to 0.356), P=0.616		B=−0.011 (95% CI −0.016 to −0.006), P<0.001	
Education	B=1.094 (95% CI 0.493 to 1.694), P<0.001		B=−0.204 (95% CI −0.039 to 0.369), P=0.016		B=0.004 (95% CI 0.001 to 0.007), P=0.024		B=0.900 (95% CI −1.051 to 2.851), P=0.364		B=0.032 (95% CI 0.011 to 0.054), P=0.003	
Presence of infarct	B=−2.278 (95% CI −6.518 to 1.963), P=0.291		B=0.247 (95% CI −0.974 to 1.469), P=0.690		B=−0.018 (95% CI −0.043 to 0.008), P=0.167		B=−28.204 (95% CI −42.270 to −14.138), P<0.001		B=−0.081 (95% CI −0.235 to 0.073), P=0.300	

*Adjusted for age and education.

Conclusion

The prevalence of brain infarcts on baseline neuroimaging was 11% in a cohort of residents of marginal housing within Vancouver, with 92% of the lesions representing SBIs. The prevalence of brain infarction in our cohort is far in excess of those in healthy community-dwelling cohorts of older individuals. Those with infarcts showed worse performance on a task of complex decision making. Our findings suggest that vulnerably housed individuals, despite having low rates of conventional modifiable vascular risk factors, are a high-risk group for stroke in need of targeted preventative health strategies.

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Disclosures

None.

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SUPPLEMENTAL MATERIAL

Data S1.

SUPPLEMENTAL METHODS

Modified Charlson Score Generation: A modified Charlson Comorbidity Index (CCI) score was calculated based on results from medical history questionnaire. Because the comorbidities included in the self-report questionnaire used did not correspond exactly to Charlson's original definitions, some conditions were excluded (Congestive heart failure, peripheral vascular disease, hemiplegia, connective tissue disease and diabetes with end organ damage). For conditions where severity variables were not available (peptic ulcer disease, moderate to severe liver disease), low and high estimates of the Charlson index for each patient was computed by weighing each answer for conditions with the lowest and highest possible Charlson weight. A previous study using this method showed no difference in mortality outcomes between the high and low estimates so the high estimates were used here.[1] The score was further modified to remove points given for previous strokes to allow for further analysis to generate a modified CCI used for analysis to adjust for co-morbidity.

Table S1. Neuroimaging protocol.

	ACQ Matrix	FOV	REC Matrix	REC Voxel (mm)	slices	slice thickness (mm)	gap (mm)	TR (ms)	TE (ms)	SENSE	Coil	Flip Angle	TI (ms)
3D T1 Sagittal	256 x 250	256 x 256	256 x 256	1.0 x 1.0	190	1	0	7.6	3.5	YES	SENSE-Head-8	8	1051
SWI Axial	444 x 216	200 x 151.351	512 x 512	0.39 x 0.39	96	2	0	30	25	YES	SENSE-Head-8	17	
FLAIR Axial	256 x 203	240 X 191.25	512 x 512	0.47 x 0.47	50	3	0	11000	125	NO	SENSE-Head-8	90	2800

Table S2. Infarct Location.

Stroke Location	Total	R	L	Bilateral
Corona radiata/centrum semiovale	3	2	1	0
Internal capsule	0	0	0	0
Caudate	7	3	4	0
Lentiform	1	0	1	0
Thalamus	1	0	1	0
Midbrain	0	0	0	0
Pons	1	0	1	0
Medulla	0	0	0	0
Cerebellum	6	2	3	2
ACA territory embolic	1	1	0	0
MCA territory embolic	1	0	1	0
PCA territory embolic	1	0	1	0
ACA/MCA watershed	1	0	0	1
MCA/PCA watershed	0	0	0	0
Other or multiple (specify)*	2	1	0	0
Total	25	9	13	3

*1: R external capsule and pons; 2: Multiple lacunes in external capsule watershed region

Table S3. Logistic Regression Model.

	Beta	Standard Error	p value	OR	95% CI for Beta	
					Lower	Upper
Age	.075	.026	.004	1.078	1.024	1.135
Total Homelessness Duration	-.074	.062	.234	.928	.822	1.049

Table S4. Demographics in Vancouver studies of vulnerably-housed and homeless participants.

Measure	HOTEL (2008-2011) imaging participants at baseline N=228	Lewis et al. (2007-2008) N=628[2]	Shannon et al. (2003-2004) N=1813[3]	Palepu et al. (2009) N=396[4]
Sampling	Community-based (all consenting tenants) at SROs	Stratified random sample of SROs	Facility-based at SROs	Randomly selected participants from 10 SROs (n=199) and homeless participants from shelters and meal programs (n=197)
Age (years)	46.4 (mean) SD 9.4	46 (mean)	42 (median)	42.0 (mean) SD 10.2
Sex (Male)	176/228 (77%)	496/628 (79%)	1375/1800 (76%)	244/393 (62%)
White	133/227 (59%)	426/628 (68%)		222/383 (58%)
Indigenous	69/227 (30%)	105/628 (17%)	498/1813 (28%)*	105/383 (27%)
Mixed/Other	25/227 (11%)	97/628 (15%)		56/383 (15%)
Average monthly income, CAD	$800 (median)	$1109 (mean)		$1074 (median)

Previous history of homelessness	165/225 (73%)	327/628 (52%)	512/1812 (28%)†	
0-8 years	45/228 (20%)	69/628 (11%)		
8-11 years	126/228 (55%)	276/628 (44%)		178/391 (46%)
12 years	32/228 (14%)	138/628 (22%)		99/391 (25%)
>12 years	25/228 (11%)	138/628 (22%)		114/391 (29%)
Active Smoker	213/227 (94%)	481/628 (77%)		
Injection drug use in past 1-6 months	125/228 (55%)		718/1813 (40%)	
Current alcohol dependence or problematic use	42/228 (18%)	126/628 (20%)		60/396 (15%)
Positive HIV status	39/228 (17%)		462/1813 (26%)	
Previous HCV infection	150/228 (66%)		868/1813 (48%)	

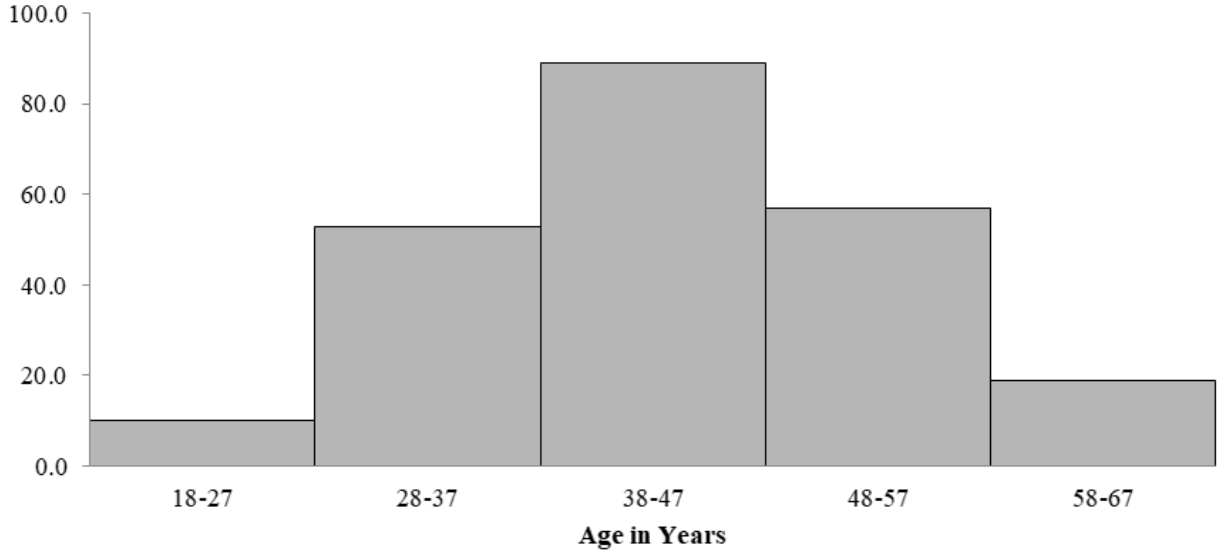
*Indigenous versus non-Indigenous reported only

Table S5. Demographics in Cross-Canada studies of vulnerably-housed and homeless participants.

Measure	**HOTEL imaging participants at baseline (2008-2011)**	**Health and Housing in Transition Study (2009)** [4, 5]			
	N=228	**Vancouver, Toronto, Ottawa N=1192**	**Vancouver N=396**	**Toronto N=399**	**Ottawa N=396**
Sampling	Community-based (all consenting tenants) at SROs	Randomly selected participants from 10 SROs or rooming houses (due to difficulties with access, modified to include meal programs, community health centres, drop-in centres); for homeless, randomly selected shelters and meal programs			
Age (years)	46.4 (mean) SD 9.4	(values presented as groups rather than mean)	42.0 (mean) SD 10.2	43.5 (mean) SD 9.9	41.1 (mean) SD 11.4
Sex (Male)	176/228 (77%)	781/1188 (66%)	244/393 (62%)	258/399 (65%)	278/395 (70%)
White	133/227	722/1156	222/383	203/379	297/393

	(59%)	(62%)	(58%)	(54%)	(76%)
Indigenous	69/227 (30%)	205/1156 (18%)	105/383 (27%)	52/379 (14%)	47/393 (12%)
Mixed/Other	25/227 (11%)	229/1156 (20%)	56/383 (15%)	124/379 (33%)	49/393 (12%)
Monthly Income, median CAD	$800	$900	$1074	$770	$825
Educational Attainment <12 years	171/228 (75%)	529/1183 (45%)	178/391 (46%)	170/397 (43%)	181/394 (46%)
Educational Attainment =12 years	32/228 (14%)	277/1183 (23.4%)	99/391 (25%)	90/397 (23%)	87/394 (22%)
Educational Attainment >12 years	25/228 (11%)	377/1183 (32%)	114/391 (29%)	137/397 (34%)	126/394 (32%)

Figure S1. Age Distribution of Participants.



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